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WIREWORMS ATTACKING CEREAL AND FORAGE CROPS.

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INTRODUCTION.

Wireworms are the larvæ of several kinds of hard-shelled beetles belonging to the family Elateridæ. The beetles are known colloquially as "click-beetles," "skip-jacks," snapping beetles, etc.[1] These names are all derived from the beetles' unique habit of snapping the forepart of the body when placed upon their backs or held between the fingers. This habit is undoubtedly of use to the beetles in righting themselves when accidently overturned, and may also be a means of escape from their predatory natural enemies.

Wireworms are elongate, more or less cylindrical, having a very highly chitinized cuticle, and measuring, according to the species, from one-half inch to over 3 inches in length. They have three pairs of short legs near the anterior end of the body. The color is usually yellow or reddish-brown. The cotton and corn wireworm is an exception to this description.

The false wireworms (fig. 1, *a*) will also answer to the above description, but can easily be distinguished by their ability to move very rapidly and by the clavate last joint of the antennæ; the true wireworms, though able to move rapidly in the soil, are not very agile when placed on the surface of the ground, and their antennæ never have clavate terminal joints. The term "wireworm" is also, though erroneously, applied to these false wireworms, which are, however, the larvæ of another group of beetles, the darkling beetles (Tenebrionidæ). These beetles can not snap the forepart of the body. One species of darkling beetle (*Tenebrio molitor* L., fig. 1, *b*) is common throughout the United States, and its larva, the meal-

[1] The Cherokee Indians recognize the large-eyed elater (*Alaus* sp.) by the name "tulskuwa," which means "one that snaps with his head." This interesting note was made by Dr. J. W. Fewkes and communicated to the writer by Mr. F. M. Webster.

worm, is found in granaries and warehouses, where it feeds upon stored products. Another genus (Eleodes) is found only in the territory west of the Mississippi River, and attacks cereal crops in the field. The name "wireworm" is also incorrectly applied to several species of millipedes (*Julus* spp., fig. 1, *c*).

The true wireworms, from an economic standpoint, are among the five worst pests to Indian corn and among the twelve worst pests to wheat and oats. They are also important pests to many other crops. Since 1841, when Dr. Thaddeus Harris first published an account of these insects,[1] the literature of economic entomology has been replete with references to their depredations, and from the standpoint of the entomologist, as to the difficulty of combating them, they probably rank second only to the white grubs (*Lachnosterna* spp.).

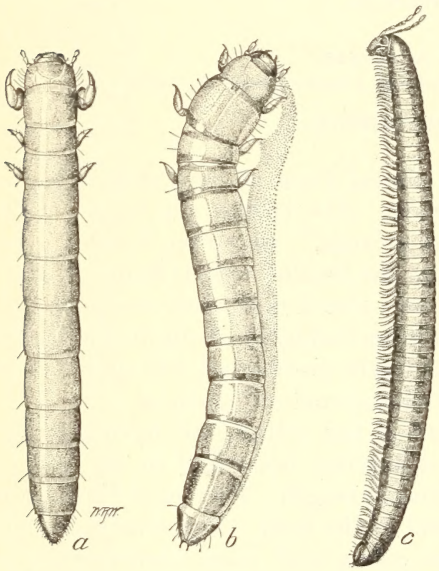

FIG. 1.—Larvæ likely to be mistaken for wireworms: *a*, False wireworm; *b*, mealworm; *c*, *Julus* sp. All enlarged. (Original.)

In view of the recently enacted Federal quarantine bill these insects assume an added interest, inasmuch as they can easily be introduced in the larval condition within fleshy roots, bulbs, and tubers. Mr. E. R. Sasscer, of the Federal Horticultural Board, recently intercepted an elaterid larva in the root of *Aralia cordata* from Japan; the larva was in good condition and is still alive in our laboratory (October, 1914). The writer has often seen the larvæ of *Agriotes mancus* Say within potato tubers that had been in a root cellar all winter.

These insects are destructive to cereal and forage crops in the larval stage only, although the adults of certain species (*Limonius discoideus* Lec., etc.) do considerable damage to the blossoms of fruit trees in the Pacific Northwest, and Fletcher reports[2] similar depredations of the adults of two other species (*Corymbites caricinus* Germ. and *C. tarsalis* Melsh.). The forms attacking cereal and

[1] Harris, T. W. Report on the Insects of Massachusetts Injurious to Vegetation, p. 46–50. Cambridge, 1841.

[2] Fletcher, James. Report of the Entomologist and Botanist, Central Experiment Farm, Canada, for 1892, p. 4. Ottawa, 1892.

forage crops confine their attention to the seed, roots, and underground stems and are exclusively subterranean, with the single exception recorded by Mr. E. O. G. Kelly, of this office, wherein he mentions finding a species (*Monocrepidius vespertinus* Fab.) damaging wheat at Wellington, Kans., by boring in the hollow of the wheat stems and not among the roots.

Their depredations are first to be noticed, with the exception of the cotton and corn wireworm, immediately after seeding, when they attack the seed, eating out the inside and leaving only the hull. When they are very numerous they often consume all the seed, making reseeding necessary, and in severe outbreaks a second reseeding is sometimes made before a stand is obtained. Aside from the extra labor and cost of the seed, this delays the planting of the crop, and if it be corn, in the Northern States the season is too short to mature so late-planted a crop and, except for the fodder, it is a failure. Where wireworms are present, even in very small numbers, corn will make a poor stand, which will necessitate the planting-in of missing hills. In some regions where these insects are quite numerous it is customary to sow three or four times the amount of seed that would normally be necessary in order to get a good stand.

KINDS OF WIREWORMS.

Several hundred species of Elateridæ occur in North America. They vary enormously in their habits, some forms living in dead and rotten wood (Alaus, Elater, Adelocera, etc.). Alaus has also been recorded as boring in solid wood, though the writer is inclined to discredit this observation, and other species live under moss (Sericosomus). A number of species abound in heavy moist soil filled with humus (Melanotus, Agriotes, etc.), while some prefer well-drained soils (Corymbites), and still others (Horistonotus) are most destructive on high sandy land which is very poor in humus. Many wireworms have been recorded as predaceous (Alaus, Hemirhipus, Adelocera, etc.). I am told by Mr. T. H. Jones, recently associated with the Rio Piedras Sugar Planters' Experiment Station, that the large luminous elaterid (*Pyrophorus luminosus* Illiger) of the West Indies is a decidedly beneficial insect, as it feeds on the Lachnosterna larvæ in the sugar-cane fields. Through the kindness of Mr. G. N. Wolcott and Mr. R. H. Van Zwalenburg I now have (October, 1914) a Pyrophorus larva from Cuba, one from Jamaica, and several from Mayaguez, P. R. All of these larvæ are living and apparently thriving on the larvæ of our native Lachnosternas. That this insect may some day be introduced into the southern United States as a natural enemy of Lachnosterna is not at all improbable. At least one instance

has been noted[1] in which a wireworm [*Lacon* (*Agrypnus*) *murinus* L.] lived in the stomach of a child. Most of our common species lay their eggs on sod or very weedy land, but the wireworms (*Corymbites* spp.) of the dry-farming country of the Pacific Northwest are severe pests on land that has been seeded to wheat, by the summer fallow method, for the past 15 years, and, as this land was originally sagebrush prairie, it probably never was in sod.

Several distinct kinds of true wireworms are destructive to cereal and forage crops in the United States; and since, as has already been stated, the different kinds vary more or less in their life histories, there is consequently a variation in the method of control as recommended in the following pages of this bulletin. It is therefore quite necessary to determine the identity of the wireworm, and to meet this necessity the many species of importance as pests to cereal and forage crops are treated separately.

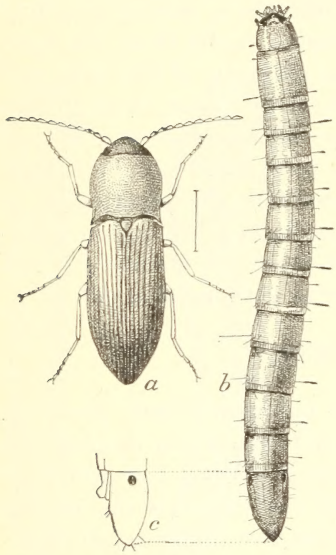

FIG. 2.—The wheat wireworm (*Agriotes mancus*): *a*, Adult beetle; *b*, larva; *c*, side view of last segment of larva. All enlarged. (From Chittenden.)

THE WHEAT WIREWORM.

(*Agriotes mancus* (Say), fig. 2.)

The adult of the wheat wireworm is a small brown beetle a little over one-fourth of an inch in length, quite robust, and moderately covered with very short, fine hair. The larva is pale yellow in color, very evenly cylindrical, and very highly polished. When full grown the larva measures about an inch in length and is about as thick as the lead in a lead pencil. These wireworms will be readily recognized by the singly pointed ninth abdominal segment and the two black spots on the upper side of this segment near its base.

This is one of the most common wireworms of the northeastern and middle western United States. A report of this species as a pest in the dry-farming regions of Washington State[2] is undoubtedly a

[1] Sandberg, G. El tilfälde af Coleopterlarvers tilhold i tarmkanalen hos et Menneske. In Entomologisk Tidskrift, v. 11, p. 77–80, 1890.

[2] Scobey, J. O'B. Wireworms. Washington Experiment Station. (State Agricultural College and School of Science.) Bulletin 4, p. 75–80, 3 figs., May, 1892.

misidentification, the insect probably being *Corymbites* sp. The wheat wireworm is normally a grass feeder, living on the roots of sod, and with the abundance of its natural food supply producing no appreciable disturbance in the meadows, but when the sod land is broken these wireworms concentrate in the drill rows or hills of corn, the usual crop to follow sod in the eastern United States, and often cause absolute failure of the crop by destroying the seed and eating off the roots of such plants as may germinate. This species is usually more destructive, therefore, on land recently broken from sod. Last year (1913) the writer investigated an outbreak in northern New York and located as many as 10 wireworms to the hill in cornfields, rendering the crop, so far as grain was concerned, an absolute failure. This year (1914) the same field was again planted in corn, and again the wireworms destroyed most of the crop.

The larvæ spend three years in the soil before transforming to beetles, so that the depredations of this pest may be looked for during the second season as well as the first following the breaking of sod.

LIFE HISTORY.

The beetles are in evidence early in the spring, and at this time can be swept from wheat and, in fact, from any vegetation around the fields, or they may be found under boards and rubbish. Mating occurs during April and May, and immediately egg-laying begins. The eggs are deposited in grasslands exclusively, so far as our observations go, the female burrowing into the ground or under rubbish to oviposit. The young larvæ feed during the ensuing summer, and, hibernating when about half grown, resume feeding the following spring. They continue to feed during the second summer and hibernate the second winter as full grown or mature larvæ. The third spring they resume feeding and continue it until early in July, when they leave the plants and form small earthen pupal cells in the soil.

In 1913 Agriotes started to pupate about July 15 in northern New York. The writer found many mature larvæ and pupæ in the fields at Bridgeport, N. Y., on the shore of Lake Oneida, on July 17, while investigating a severe outbreak of this pest on the farm of Mr. C. J. Fisher. Other larvæ collected at Bridgeport pupated as late as August 12. In 1914 several hundred larvæ were reared in the Hagerstown laboratory. All that became adult this year pupated between the middle and the end of July. The pupal stage varied in duration from 15 to 21 days.

Specimens collected by Mr. J. J. Davis, of this bureau, at Watertown, Wis., pupated on August 8. Mr. Pettit found the pupæ in

the rearing cages on August 26 and adults emerged as late as the middle of September at Grimsby, Ontario, Canada.[1]

The pupal stage usually lasts from 15 to 19 days. One specimen collected at Watertown, Wis., by Mr. Davis pupated on August 8 and the adult emerged August 19. A specimen collected at Bridgeport, N. Y., pupated on August 12 and emerged September 1. Other specimens collected July 25 at the latter place became adult August 12.

The pupal chamber consists of an oval cell, the long axis of which is perpendicular, located at a uniform depth of about 5 inches below the surface of the soil. The dust mulch in the case under discussion was 4 inches deep and the pupal cells were about 1 inch deeper than cultivation in the moist, firm soil. The pupa stands erect in the cell with the head upward, the larval exuvium being at the bottom of the cell.

The adult evidently passes the remainder of the summer in the pupal cell, in which it also later hibernates. Matured adults were found in these cells in the fields at Bridgeport, N. Y., as late as September 15, and in our rearing cages adults passed the winter without feeding or drinking.

Three distinct generations of larvæ were collected in the field in the summer of 1913—full-grown larvæ about to pupate, half-grown larvæ, and larvæ about one-fourth inch long—actively feeding on the corn. We have now in the laboratory, subject to outdoor temperature, two distinct generations of larvæ collected in the summer of 1913. The first generation—that is, the largest larvæ collected—all transformed to adults during August. Mr. Pettit and several others have made similar observations, and there is no doubt that this species, at least in the northeastern United States, spends three years as a larva.

FOOD PLANTS.

Agriotes mancus was observed at Bridgeport, N. Y., feeding upon corn seed and roots, potato tubers, wheat roots, carrots, and the underground stems of string beans; a single specimen was also found within the stem of the common field mushroom (*Agaricus campestris*). Other writers have found it attacking the cucumber, turnip, and cabbage. Mr. Theo. Pergande, of this bureau, records[2] a larva of this species feeding on the larva of a lamellicorn beetle in one of his rearing cages. The writer is of the opinion, however, that normally this species is not predaceous.

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[1] Pettit, J. Description of the wheat wireworm (*Agriotes mancus* Say). *In* Canad. Ent., v. 4, No. 1, p. 3–6, fig. 1, January, 1872.

[2] U. S. Dept. Agr., Div. Ent., Notes, v. 4, No. 2795, Oct. 5, 1882.

REMEDIAL MEASURES.

We recommend plowing sod land immediately after the first hay cutting, usually early in July, when the land is intended for corn the following year. This land should be cultivated deeply throughout the remainder of the summer. Land that is in corn and badly infested should be deeply cultivated even at the risk of slightly "root-pruning" the corn. This cultivation should be continued as long as the corn can be cultivated, and as soon as the crop is removed the field should be very thoroughly cultivated before sowing to wheat. In regions where wheat is seeded down for hay any treatment of infested wheat fields is precluded. Where wheat is not followed by seeding, the field should be ploughed as soon as the wheat is harvested.

Thorough preparation of the corn seed bed and a liberal use of barnyard manure or other fertilizer will often give a fair stand of corn in spite of the wireworms, a vigorous plant often being able to produce roots enough to withstand the depredations of several wireworms.

Though we realize that usually this is not practicable, the interposing of a crop not severely attacked by wireworms, such as field peas and buckwheat, between sod and corn would materially reduce the number of wireworms in the soil when the corn was planted.

THE CORN AND COTTON WIREWORM.

(*Horistonotus uhlerii* Horn, fig. 3.)

The adults of the corn and cotton wireworm are small, slender, and dusky brown; the largest is a trifle over three-sixteenths of an inch in length and can easily be distinguished from other forms infesting cereal crops by the heart-shaped scutellum. The wireworms of this tribe (Cardiophorini) are very unlike any of the other wireworms. They are not hard and wiry, but soft, membranous, and elongate. The body, which is usually white, appears to be composed of 26 segments, every third segment being swollen. The last segment is simply pointed. The head, which is yellow, is long and slender, with a pair of very prominent dark-brown jaws. When full grown these wireworms measure about an inch in length and are but little thicker than pack thread.

Unlike most of the eastern wireworms, which are usually most destructive in damp, low-lying fields, these insects seem to be far more numerous on the higher parts of the fields in light sandy soil.

These wireworms are among the most troublesome species of the southern United States. Mr. W. A. Thomas records[1] one species of

[1] Thomas, W. A. Corn and Cotton Wireworm (*Horistonotus curiatus* Say). So. Car. Agr. Exp. Sta., Bul. 155, 10 p., figs. [i. e., pls.] 6, March, 1911. I have since been informed by Mr Conradi that this is a misidentification and that the species in question is *H. uhlerii*.

this genus (*Horistonotus curiatus* Say) as one of the worst pests in South Carolina.

Mr. Vernon King, of this office, is at present investigating a very serious outbreak of *Horistonotus uhlerii* in Missouri and has prepared the following preliminary account of this species:

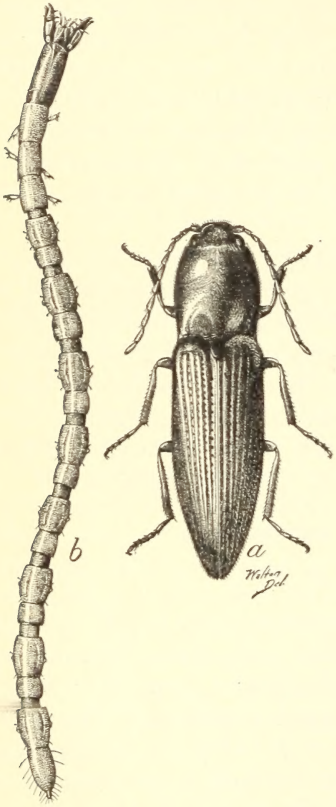

FIG. 3.—The corn and cotton wireworm (*Horistonotus uhlerii*): *a*, Adult beetle; *b*, larva. Enlarged. (Original.)

Horistonotus uhlerii Horn is a serious pest to corn in southeastern Missouri, and to corn, cotton, and cowpeas in northeastern Arkansas, and has been reported from the Carolinas and Illinois.

The larvæ may be found about the roots of their host plants in large numbers, nearly 50 having been taken from one hill of corn. Adults, pupæ, and larvæ can be seen in June, all beneath the surface of the soil, and later the adults will be found above the ground, resting on the plants. The eggs are probably laid about the end of June in the soil, on or about the roots of corn and cowpeas, for minute larvæ have been taken early in July. In May and June the larvæ are most plentiful, but as the season advances they become scarce, and finally disappear by the time winter sets in. By the third week in August the adults can no longer be found. Under laboratory conditions the larvæ pass the winter partly grown, and no doubt in nature they hibernate in the same form, but in what location is not yet known.

Although corn, cowpeas, and cotton are the main hosts of this insect, the larvæ feed on the roots of Johnson grass (*Sorghum halepense*) and have been reported as feeding on crab grass.

Infested corn plants become wilted and stunted, with leaves of a bluish shade, and brown at the tips, standing out from the stalk stiffly instead of bending over gracefully as in a healthy plant. Deprived of most of the roots through the work of the larvæ, the plant can be pulled up with little effort. Weak individuals soon succumb, leaving gaps in the rows, but the more vigorous plants put forth new roots in abnormal numbers. These are matted together and distorted, and although the plants survive, only nubbins are produced. Tall and apparently healthy plants may have larvæ among the roots without damaging the corn materially. The infestation, therefore, is not confined to the impoverished areas.

In cowpeas the fibrous roots suffer most, the thicker roots being perforated, so that the plants become yellow and dwarfed and fail to vine.

Cotton is injured in the early stages by the larvæ boring into the seed and injuring the very young plants, checking the growth so much that the plant dies or struggles along only to produce little or no cotton.

Rolling land infested by this insect presents a patchy appearance, the sandy knolls standing out distinct and bare, being overgrown later with weeds, particularly crab grass, briers, and morning-glory.

The infestation seems to be worst after a crop of cowpeas, but the exact significance of this crop in relation to wireworm injury has yet to be determined. Applications of barnyard manure and of wood ashes have had no effect in checking this pest. On account of the susceptibility of the larvæ and pupæ to exposure, plowing the soil in the heat of the sun would undoubtedly destroy many of the wireworms. The objection to this method, however, would be that the planter is occupied with other farm operations at that time, and also there would be difficulty in getting at these areas, which are often scattered, irregular, and isolated. From the data thus far gathered we can not say what effect fall plowing would have on this insect. Further investigation, however, will in all probability give a clue to remedial measures.

WIREWORMS OF THE GENUS CORYMBITES.

In the literature of American economic entomology there is no reference to beetles of the genus Corymbites as pests to cereal and forage crops. In the Pacific Northwest two species (*C. inflatus* Say and *C. noxious* Hyslop) are among the worst pests to cereal crops. The habits of the two species are quite distinct and will be treated separately. The occurrence of *Corymbites cylindriformis* Hbst. in enormous numbers in alfalfa and wheat fields about Hagerstown, Md., this spring (1914), and the finding of Corymbites larvæ in these fields at various times, might indicate that the genus is represented among the cereal and forage pests in this region also.

In Europe the habits of several species of this genus have been recorded by Schiodte and Perris. *C. pectinicornis* L., *C. castaneus* L., and *C. sjlandicus* Müll. are found living in woody meadows and *C. æneus* Fal. is found in fields.[1]

C. latus Fab. is recorded [2] as living "in the ground like other insect larvæ, feeding on roots * * *. They cause great damage to carnations in flower gardens." Following is a note by Mr. Pergande from the Bureau of Entomology files:[3] "Elaterid larva in apple tree, received from B. C. Hawkins, Horse Cove, Macon County, N. C. A larva of an elaterid found in a boring in trunk of apple with a dead larva of *Saperda bivittata*."

This note, though the correctness of the determination of the wireworm is not certain, is interesting, inasmuch as it seems to indicate that some species of Elateridæ now classified as Corymbites are

1 Schiodte, J. C. De metamorphosi eleutheratorum observationes, pt. 5, p. 520–522, pl. 8, fig. 9–10, pl. 10, fig. 4, 1871.

2 Perris, Édouard. Larves des Coléoptères, p. 179. Paris, 1877. "Cette larve vit dans la terree soit d'autres larves ou insectes, soit de racines. M. de Bonvouloir, en m'en envoyant des echantillons, me l'a signalée comme causant de grands degâts aux œillets de son parterre."

3 U. S. Dept. Agr., Div. Ent., Notes, v. 8, No. 6187, Apr. 3, 1894.

predaceous, while other forms also in this genus are known to be exclusively vegetable feeders.

During the spring of 1909 a reconnoissance was made to determine the extent and nature of the damage being done by these insects. Circular letters with blank forms inclosed were sent to the agents of the warehouse and elevator companies at most of the large grain-shipping points in the Pacific Northwest. These men are very intimately in touch with the farmers and usually know of any serious depredations that are likely to affect the production of grain. From their replies we found that corn was being seriously damaged at Spokane, Pullman, Kiona, Johnson, and Colville, in Washington, and Latah and Mineral in Idaho; oats were being almost completely destroyed at Ritzville, Downs, Espanola, Govan, and Vancouver, in Washington, and Moscow and Latah in Idaho; and that wheat was being damaged at Wilbur, Connell, and Govan in Washington. The fact that damage to wheat was not reported from more localities does not signify that wheat is less susceptible to the attacks of these insects. The buyers will not report any damage to wheat for fear of starting a scare among the farmers and thereby abnormally raising the price asked when the buying opens in the fall.

THE INFLATED WIREWORM.

(*Corymbites inflatus* Say.)

The inflated wireworm occurs throughout most of the northern United States, but is limited as a pest to cereal crops, so far as our observations now record, to the regions of eastern Washington and Oregon and western Idaho, known as the semiarid Transition Zone and characterized, when not under cultivation, by the presence of bunch grass (*Agropyron spicatum*) and June grass (*Poa sandbergii*) and by the absence of sagebrush. This region is only partly summer fallowed, crops often being grown on the same land for several consecutive years.

The beetle is robust, but little more than one-fourth of an inch in length, and of a slate-gray color, sometimes being almost black. The wireworm is about one-half inch long, depressed, with a pair of backwardly directed spurs on the ninth abdominal segment, and pale yellow.

In the spring of 1909 Mr. George I. Reeves, of this bureau, recorded finding the larvæ of the inflated wireworm damaging seed corn at Pullman, Wash. His observations were carried on principally in the cornfield of a Mr. Curtis, north of the town. On this farm he found from 4 to 10 larvæ to the hill when he first investigated the outbreak, on May 24, 1909. The wireworms were in various stages of

development and were feeding on the seed, which had been planted on May 10 and 17, eating out the kernels and leaving only empty hulls. Usually the roots of such plants as had escaped were not damaged. The particular field under observation had been in oats in 1908 and in wheat in 1907. On June 1 Mr. Reeves again examined this field and then found the stand very poor, and the wireworms seemed to be more numerous than when he first examined it, as from 18 to 20 were to be found in nearly every hill. At this point the investigations were turned over to the writer.

On June 20 the entire field was harrowed and reseeded, the first seeding being absolutely destroyed by these wireworms. The second seeding started very well and looked as though it would succeed. Many wireworms were still present, however, and by July 8 the second seeding was about half destroyed and had to be planted in by hand. The season was then so well advanced that the crop was practically a failure.

LIFE HISTORY.

Early in May the beetles emerge from the pupal cells in which they pass the winter, a number of beetles having been caught at Pullman, Wash., by Mr. Reeves as early as May 5, 1908. They are about in enormous numbers during late May and early June. On May 28, 1910, the writer collected over a hundred of these beetles in a few minutes from some rosebushes in a fence row along the side of a last year's wheat field. The beetles continue abundant until early July, and by the middle of this month they have all disappeared but a few stragglers. During June the beetles mate and lay their eggs. The larvæ feed during this summer and pass their first winter about half grown. They resume feeding the following spring and continue to feed during the second summer, passing the second winter as nearly mature larvæ. The larval life is completed early the third spring, when they transform to pupæ during late June and early July. The last transformation takes place in late July and early August, and the adult beetles remain in the pupal cells from that time until early the fourth spring. Thus the wireworm, as such, is in the ground during the growing season of three years.

FOOD PLANTS.

The beetles of this species were observed in large numbers during May, 1910, at Pullman, Wash., on wild rosebushes, where they were apparently eating the petals of the unopened rosebuds, as many as 10 beetles having been counted on a single bud and the buds being

badly riddled with holes. In a rearing cage the beetles were observed eating into kernels of wheat which were exposed on the surface of the ground. The beetles are also to be collected in large numbers in clover fields. The larvæ, so far as our records show, attack corn, wheat, and potatoes. They also undoubtedly attack oats and barley.

THE DRY-LAND WIREWORM.

(*Corymbites noxius* Hyslop,[1] fig. 4.)

The dry-land wireworm, so far as we at present know, is confined to the Upper Sonoran Zone of Washington State, though it will undoubtedly be found in the Upper Sonoran of Oregon. This zone is

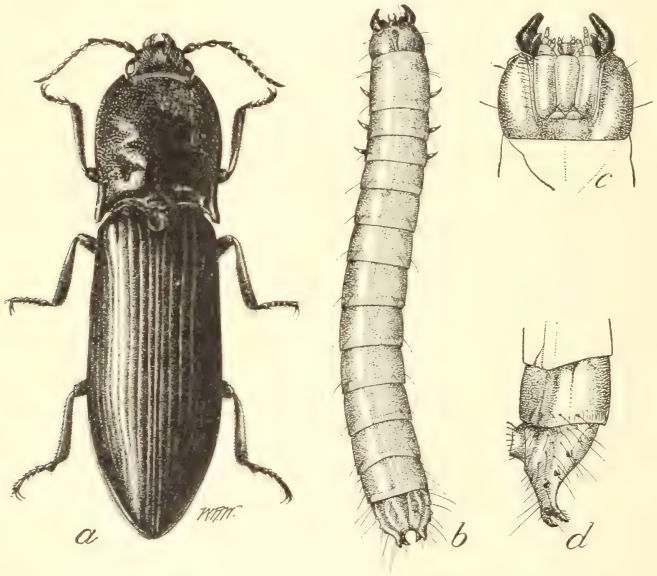

FIG. 4.—The dry-land wireworm (*Corymbites noxius*): *a*, Adult; *b*, larva; *c*, under surface of head of larva; *d*, side of last segment of larva. *a*, *b*, enlarged; *c*, *d*, more enlarged. (Original.)

characterized by the presence of sagebrush and occupies that part of Washington lying south of the Columbia River, east of the Cascade Mountains, and west of the semiarid Transition Zone, extending up the Snake River into Idaho and across the Columbia River into Oregon. This region is almost exclusively dry-farming country, summer fallowing being necessary to obtain enough moisture to mature wheat and other cereals.

[1] Hyslop, J. A. Description of a new species of Corymbites from the Sonoran Zone of Washington State (Coleoptera, Elateridæ). *In* Proc. Biol. Soc. Wash., v. 27, p. 69–70, Mar. 20, 1914.

The beetle of this species is about one-half inch long, quite slender, and jet black in color. The wireworm is very similar to the inflated wireworm.

Early in April, 1910, our attention was called to a series of severe wireworm outbreaks in the region above outlined. On the 5th of the month the farm of a Mr. Dunnigan, at Connell, Wash., was visited. He was at that time reseeding 1,800 acres of wheat which had been killed out by these wireworms. From Connell we proceeded to Govan, Wash., and here we found the wireworms also doing considerable damage. In a fallow field that had been ruined by wireworms when in oats in 1909 we found them in enormous numbers. These wireworms when in the field are usually to be found between the dust mulch and the moister earth below. This species is more or less destructive throughout its range. During 1910 reports of severe outbreaks were received from eight wheat-receiving stations in the States of Washington and Idaho.

LIFE HISTORY.

This beetle is about during June and July, at which time it deposits its eggs in wheat fields, weedy fallow fields, and volunteer wheat on fallow land. The eggs are undoubtedly laid underground by the female burrowing into the soft earth, as many adults were collected in the fields at a depth of from 5 to 8 inches below the surface which were not in pupal cells. Mr. J. E. Graf, of the Bureau of Entomology, has found this to be the case with the sugar-beet wireworm.[2] The young larvæ are to be found in the soil during August and the remainder of the summer, but their depredations are not noticeable at this time, as, in the region where the species occurs, wheat is the only extensively grown crop. The young wireworms pass their first winter in the soil at a depth of from 12 to 20 inches below the surface. The following spring and summer they spend in the summer fallow and are not noticed. Their second winter they again hibernate as wireworms, and in the spring of their third year, the field being now planted to wheat, they turn their attention to the seed and young plants, and it is at this time that their depredations are so startlingly noticeable. They feed during late March, April, and May, and early in June burrow to from 4 to 8 inches below the surface, making small oval cells, in which the very fat larvæ lie in an inactive condition during June, July, and early August, when they pupate and the adults emerge from the pupal skins the middle of that month, but remain in the pupal cells the remainder of that summer and the ensuing winter, not emerging from the ground until the fourth spring from that in which the eggs were laid.

[2] Graf, John E. A Preliminary Report on the Sugar-Beet Wireworm. U. S. Dept. Agr., Bur. Ent., Bul. 123, p. 18, Feb. 28, 1914.

In the spring of 1910 a large number of these larvæ were collected in the wheat fields at Govan and Wilbur, in Washington State, and confined in a root cage made by sinking a molasses barrel to the level of the earth surface in a field at Govan and closing the top with a short cylinder of sheet iron covered with wire gauze. The barrel was filled with earth and wheat planted therein. The larvæ could easily be separated into three distinct groups, according to size, which indicated a 3 years' life cycle. Later observations on the material in the rearing cage proved this to be actually the case.

Two lots of larvæ were confined in this cage—one on April 14 and the other on April 30, 1910, so that all must have hatched from eggs laid in 1909 or previous to that year. On June 21 the cage was examined and a number of the larvæ were found to be at from 4 to 8 inches below the surface, resting quietly in oval cells. They were very fat at this time. The cage was not examined again until November 4, and at this time 3 adults, evidently of the 1907 generation, were found at about the same depth as the larvæ observed in June. They were still in the pupal cells, as was evident from the last larval skins and the pupal skins found with them. The following spring (1911) the cage was examined on March 29. Several larvæ were found at this time. They were now moving actively about in the soil and almost immediately attacked some seed wheat sown in the cage on this date. An adult still in the pupal cell was also found at this time. The cage was next examined on July 4, at which time an adult was found on the surface of the ground. Several full-grown larvæ were also found on this date in their cells at the usual depth of from 4 to 8 inches below the surface. These were evidently the larvæ hatched from eggs laid in 1908. On August 17 the cage was examined and at about 5 inches below the surface a pupa and an adult were found. The latter had evidently just transformed, as it had not yet become quite black and was still very soft. The following day the cage was entirely emptied and at between 18 and 20 inches below the surface 10 larvæ and an adult were found in soil that was very hard, and very slightly moistened, in fact merely moist enough to prevent its being absolutely dry. The larvæ seemed to be full grown and had evidently just completed a molt, as they were quite soft. These were evidently of the 1909 generation.

REMEDIAL MEASURES.

As will be seen from the life histories of these two species, the generations about to become adult are inactive larvæ from June to August and very delicate pupæ during the early part of the latter month. These resting larvæ and pupæ are usually at a depth of from 4 to 8 inches below the surface, and any disturb-

ance of the soil to that depth at this time would undoubtedly destroy them. At this time of the year the ground is very hot and the air exceedingly dry in this region, and even the resting larvæ and pupæ that were not actually crushed by the cultivation would soon succumb to drying when their cells were broken open. The writer had considerable trouble in bringing pupæ in from the field to his rearing cages and was forced to resort to tightly closed tin boxes which were fitted in the bottom with moistened blotters.

The usual farm practice in the region where the dry-land wireworm is troublesome may be roughly outlined as follows: Immediately after seeding the wheat in early spring the fallow land is plowed to a depth of from 4 to 7 inches. This is usually in April, but if horses and help can be spared from seeding, the summer fallow is plowed as early in the spring as the land can be worked. The next operation on the fallow land is disking it late in June or early in July to maintain the dust mulch and kill out the weeds and volunteer wheat. Many of the more progressive farmers now advocate, and a few practice, fall plowing of stubble and only disking the fallow land in the spring. The year following the summer fallowing the field is disk harrowed early in the spring if the land has run together during the winter and is caked; otherwise the land is harrowed with a drag or spike-tooth harrow. It is then seeded and dragged and receives no further treatment until harvest. The seeder is usually set to sow at a depth of about 3 inches, though if the moisture is high enough 1 inch is sufficient. Wheat hay is used extensively in this country and is cut while the wheat is in the dough, which is usually from July 4 to 15. The wheat crop is harvested from the 1st of August until the 1st of September.

We recommend altering this practice in order to destroy wireworms in the following manner:

(1) *Disk or drag harrow* the summer fallow as early as possible *in the spring*, in order to produce a dust mulch and thereby conserve the accumulated winter's moisture: (2) *continue disking* as often as is necessary to maintain the dust mulch and keep down the weeds; (3) *plow the summer fallow* in July or early in August, and immediately drag; (4) *plow the stubble* as soon as the crop is off.

As these worms are of three different ages in most infested fields, and as only about one-third of these will be in the pupal stage each year, it is evident that the first year of this practice will not show startling results. However, if the practice is continued for a couple of years it will undoubtedly reduce the number of these pests very considerably. Aside from its beneficial results in killing insects, this method of handling the land will materially reduce the weeds. The early disking merely softens up the soil and allows all the weed

seed present to sprout, and the entire crop of weeds is subsequently destroyed by the summer plowing. By the present method of farming the weed seeds are turned down to such a depth that many can not germinate, but lie dormant and sprout whenever they happen to be brought to the surface by subsequent cultivation. One crop of weed seed is in this manner often a pest for several succeeding years.

A slight variation of these suggestions will readily adapt them to the more humid sections inhabited by the inflated wireworm.

THE CORN WIREWORMS.

Several species of beetles belonging to the genus Melanotus are recorded as pests to cereal and forage crops in the United States. The beetles usually range from medium-sized to large forms measuring from one-half to three-fourths inch in length. They vary in color from light reddish-brown to almost black. The beetles of this genus can always be distinguished with a low-power lens by the comb-like claws on the last tarsal segment.

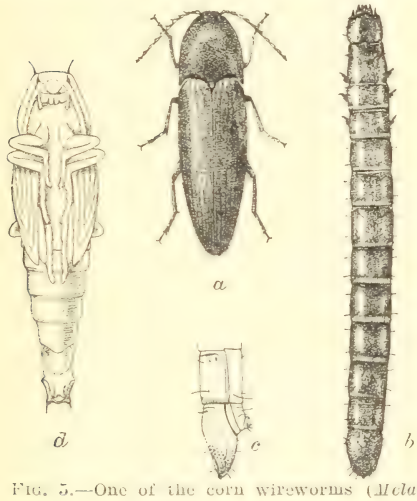

FIG. 5.—One of the corn wireworms (*Melanotus communis*): *a*, Adult; *b*, larva; *c*, last segments of same; *d*, pupa. All enlarged. (From Chittenden.)

The wireworms are reddish-brown in color, about 1¼ inches long, cylindrical in shape, and always with the last joint of the body ending in three inconspicuous lobes.

Many species of this genus inhabit decaying logs, and several writers record them as predaceous.[1] A note in the Bureau of Entomology files,[2] by Mr. Pergande, records a larva of this genus as feeding on the eggs of a locust, or grasshopper. A similar record,[3] dated September 19, 1884, is made by the same observer, wherein a Melanotus larva was found with locust eggs and reared to the adult condition by feeding on potato and dead beetle (lamellicorn) larvæ.

These wireworms are a pest to cereal and forage crops in the Middle Atlantic States, the New England States, and in the Mississippi Valley from Kansas northward. Forbes places *Melanotus communis*

[1] Perris, Édouard. Histoire des insectes du pin maritime. *In* Ann. Soc. Ent. France, ser. 3, T. 2, p. 139 (séances du 13. Avril, 1853).

[2] U. S. Dept. Agr., Div. Ent., Notes, v. 4, No. 2883, Oct. 9, 1882.

[3] U. S. Dept. Agr., Div. Ent., Notes, v. 4, No. 2884, Sept. 19, 1884.

Gyll. (fig. 5) and *M. fissilis* (Say) as among the important corn pests of Illinois. Webster found *M. communis* a very serious pest in Indiana and Ohio; Comstock and Slingerland consider *M. communis* one of the worst wireworms in New York State; and Swenk records serious depredations of *M. cribulosus* Lec., *M. communis*, and *M. fissilis* in Nebraska.

In 1907 Mr. E. O. G. Kelly found a species of Melanotus attacking corn in North Dakota. In 1910 Mr. W. W. Yothers, of this bureau, investigated a very severe outbreak of these wireworms at Corry, Pa. At the time he visited the fields as many as 7 to 15 larvæ were to be found in nearly every hill. This field had been broken from sod in 1908. In 1912 Mr. Kelly found the larvæ of *Melanotus communis* so numerous at Wellington, Kans., that they entirely destroyed his experimental corn plantings. He also found the larvæ of this species attacking kafir seed at Mulvane, Kans., in the spring of 1912. In places they had completely eaten out the seed for spaces of from 4 to 6 feet in the drill rows. In 1914 we received reports of damage by wireworms belonging to the genus Melanotus from seven localities in Indiana, seven in Wisconsin, six in Maryland, three in Michigan, three in Iowa, and one each in Alabama, Ohio, Virginia, Kentucky, North Dakota, Vermont, and West Virginia.

Several species occur on the west coast, and *M. communis* is reported as a pest to wheat in Garfield County, Wash.,[1] but the writer is inclined to believe that the pest in this case was either a false wireworm or a species of Corymbites.

Mr. Pergande records[2] this species as attacking lettuce roots, wheat, and potatoes.

LIFE HISTORY.

The adults of these wireworms are flying about in late April, May, and June, when they undoubtedly deposit their eggs in the grasslands. The larvæ spend two to five years in the soil. That any have so short a life-cycle period as two years is not at all certain. We have, however, in our outdoor insectary, larvæ received from Inman, Nebr., April 19, 1912, subject to very nearly natural conditions. These larvæ were well grown when received and were at least of the 1911 generation. At the date of this writing (October, 1914) they are larvæ. They have passed the summers of 1911, 1912, 1913, and 1914 in the soil, and if they pupate next summer (1915) the adults will, without doubt, remain in the pupal cells until the spring of 1916, making, in this case, five full years from egg to egg. These beetles pupate during July and early August.

[1] Scobey, J. O'B. Wireworms. Wash. Exp. Sta. (State Agr. Coll. and School of Sci.), Bull. 4, p. 75, May, 1892.

[2] U. S. Dept. Agr., Div. Ent., Notes, v. 4, No. 2884.

Mr. Webster found pupæ in the ground August 19, 1885, at La Fayette, Ind.

At the Hagerstown Laboratory over 100 larvæ of this genus are under observation. Those that emerged as adults this year pupated between the end of July and the middle of August. The pupal stage varied in duration from 12 to 22 days.

The adults do not leave the pupal cells, however, until the following spring. Mr. Webster found adults of *M. communis* in pupal cells on March 17, 1894, at Wooster, Ohio, and the writer found an adult in a wheat field at Hagerstown, Md., on November 22, 1912. This adult was in a cell with its pupal and last larval exuvia. The cell was 1 inch below the surface, in the drill row in which several consecutive plants had been killed.

REMEDIAL MEASURES.

The larvæ of the genus *Melanotus*, so far as our observations go, are confined to poorly drained and usually to heavy, sour soil. In making a survey of Birch Creek and Eel Creek bottoms in Clay County, Ind., we were informed by nearly all of the farmers that up to within the past four years wireworms caused very large annual losses to corn growers, while for the past three years this pest has been quite unknown to them. Coincident with the disappearance of the wireworms we find that the land was tile-drained on most of the farms. That the tile drainage of the land was actually responsible for the disappearance of the wireworms is more than we are prepared to say. However, the coincidence is very suggestive.

WIREWORMS OF MINOR IMPORTANCE.

The following species, though not serious pests to cereal and forage crops over extensive areas, are, during certain seasons, very destructive in restricted localities.

The wireworms belonging to the genus Limonius are among the most important of this group. In 1909 the writer received report of serious damage being done to corn and potatoes at Spokane, Wash. The outbreak was investigated and proved to be very severe, but at the time no larvæ were reared. This year (1914), through the kindness of Mr. William Tews, of Spokane, the writer received a large number of these wireworms with the report of another serious outbreak. From this material we succeeded in rearing adults which are Limonius (species undetermined). The confused wireworm (*Limonius confusus* Lec.) has made its appearance in Illinois[1] within the last few years, and although its principal damage was confined to potatoes, it was also destructive to corn. The beetle is

[1] Davis, J. J. Preliminary report on the more important insects of the truck gardens of Illinois. *In* Ill. Farmers' Inst. 16th Ann. Rpt., p. 216–263, 42 figs. Springfield, 1911. Wireworms. *Limonius confusus* Lec., p. 251, figs. 36–37.

about three-sixteenths of an inch long, reddish-brown in color, and moderately hairy. The wireworm is about three-fourths of an inch in length and is depressed, with a shallow emargination in the terminal segment; the color, as in the beetle, is reddish-brown.

The species is recorded as attacking corn, potatoes, tomatoes, onions, cabbage, radishes, turnips, horseradish, and spinach. It burrows into the underground parts of the plants, quite ruining them for market purposes, and in the case of corn, tomatoes, cabbage, and onions often kills the plant. This species does not seem to attack beans, peas, cucumbers, melons, rhubarb, lettuce, and peppers, and these crops might be of value in clearing a badly infested field prior to seeding it to grain.

The sugar-beet wireworm (*Limonius californicus* Mann.) is a very serious pest to alfalfa and corn over restricted areas in California.[1] Alfalfa is so badly infested in certain localities that it has to be plowed out and reseeded every three or four years. This species lays its eggs during late April. The eggs hatch during late May and the larvæ spend the remainder of that season and the whole of the two succeeding seasons in the ground. They pupate during July and August of their third summer, the adults remaining in the pupal cells until the spring of the fourth year. Alfalfa fields badly infested with this wireworm should be plowed out immediately after the first crop is harvested and harrowed several times before reseeding. Land intended for corn should be plowed in late July or August of the year preceding cropping. Land in corn should be deeply cultivated during August.

The abbreviated wireworm (*Cryptohypnus abbreviatus* (Say)) occurs over the entire northern part of the United States, being quite common in New England and New York, and is recorded from New Jersey by Smith.[2] In the upper Mississippi Valley this species is also a pest and specimens have been collected in Utah and Washington.

The beetles of this species are very small, being little over three-sixteenths inch in length and quite broad and flattened. The color is very dark brown to almost black and the forepart of the body is very shiny. An obscure yellowish spot ornaments each wing cover near the tip. The legs are also obscure reddish-yellow.

The wireworm is about one-half inch long, flattened, with a pair of backwardly directed prongs on the ninth abdominal segment, and is pale yellow in color.

Owing to the confusion of this wireworm with *Drasterius elegans* Fab., the literature relative to either of these insects is very unre-

[1] Graf, John E. A Preliminary Report of the Sugar-Beet Wireworm. U. S. Dept. Agr., Bur. Ent., Bul. 123, 68 p., 9 figs., 23 pl., Feb. 28, 1914.

[2] Smith, J. B. Catalogue of the Insects Found in New Jersey, p. 159. Trenton, 1890.

liable. The best account of the species of which we are cognizant is that of Comstock and Slingerland.[1]

On March 13, 1912, Mr. J. J. Davis received a communication reporting a very bad outbreak of wireworms on corn at Watertown, Wis., in 1911. The fields attacked were low-lying peaty muck-lands that had been reclaimed by tile draining. The correspondent said that he "plowed up a strip of land early last spring and turned up these insects by the millions, so that some of the furrows looked real white." Larvæ were inclosed with this communication and proved to be of this beetle. In June, 1913, Mr. Davis visited this locality and collected a number of the larvæ and sent them to the writer alive. They were confined in rearing cages on June 6, August 5 a pupa was found, and on August 14 the adult emerged from the pupa. Another larva pupated on September 2 and the adult emerged on September 11. These two records limit the pupal stage to nine days.

For this species we recommend plowing sodland, intended for corn the succeeding year, *during late August*. Cultivate corn as late as possible, and plow small-grain stubble during August, if possible.

Another genus of importance in this group is Monocrepidius. The two species of this genus recorded as attacking cereal and forage crops in the United States are quite distinct. One (*Monocrepidius lividus* DeG.) is a large species over one-half inch in length, of a dull, even brown color. It is shaped very much like a Melanotus, but can easily be distinguished from that genus by the simple tarsal claws. The other species (*Monocrepidius vespertinus* Fab.) is a small elongate beetle, a little over one-fourth inch long. The body is prettily marked with yellow and dark brown. Both of these species are more or less southern in distribution, *M. lividus* DeG. being distributed over the entire southern part of the United States from Florida to Texas and northward to northern New Jersey, scattering specimens being collected as far north as Massachusetts, while *M. vespertinus* covers the same territory, but is more generally distributed northward.

A third species, *Monocrepidius bellus* Say, is a very small form, the beetle being hardly three-sixteenths of an inch long. This species is quite often taken in cornfields during the summer and under stones in pastures during the winter about Hagerstown, Md. Dr. F. H. Chittenden[2] records this species as having been reared from larvæ feeding on the roots of creeping bent (*Agrostis stolonifera*) on the department grounds at Washington.

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[1] Comstock, J. H., and Slingerland, M. V. Wireworms. Cornell Univ. Agr. Exp. Sta., Bul. 33, p. 270, Nov., 1891.

[2] U. S. Dept. Agr., Div. Ent., Notes, v. 10, No. 7472.

Monocrepidius auritus Hbst. is also quite common about Hagerstown, adults being often found hibernating with *Drasterius amabilis* Lec. under stones. Mr. C. M. Packard, of the Hagerstown laboratory, collected a pupa of this species in the insectary garden on August 11, 1913. The adult emerged from this pupa on August 16. This year (1914) Mr. J. J. Davis sent the writer a large number of larvæ of this species from Indiana. The last two species will probably eventually be found to attack crops.

The largest, and in the southwest the most important, species of this genus is *Monocrepidius lividus* DeG. In the bureau files is a note made by Mr. Pergande, dated June 6, 1881.[1] Larvæ were found in hills of recently seeded sorghum. No locality accompanies this note. On July 4 one of the larvæ transformed to a pupa, and on July 11 the adult issued, making the pupal period just a week.

Mr. Kelly collected an adult in a hay pile March 21, 1911, and also a larva of this species burrowing in a young corn plant at Wellington, Kans., on June 11, 1910. This larva pupated on September 8, but was not reared to an adult. He also collected an adult in an alfalfa field on May 10 of that year. Another larva, supposed to be this species, was collected June 12 and was kept alive in a rearing cage until November 25, indicating that the species hibernates in the larval state. The particular specimen, however, died during the winter.

During July, 1911, Mr. G. G. Ainslie found the adults of this species on the fresh silk on the corn ears down in the tip of the husk. He found them in the act of eating the corn silk and also the pollen.

The writer, while investigating an outbreak of the "curlew bug" (*Sphenophorus callosus* Oliv.) at Hartford, N. C., found several of these wireworms in a cornfield. These larvæ were collected on November 4, 1911, and by December of that year one of the larvæ had eaten all his comrades and had gone into hibernation in the rearing cage in the office at Washington. The data relative to the life history of this individual can not be relied upon as of value in determining the normal life history, as the office was subjected to great extremes of temperature that winter, often freezing at night and being over 80° F. by noon. However, this larva transformed to a pupa and emerged as an adult between May 21 and June 7, 1912. This beetle lived in the rearing cage without food until July 24 of that year. Mr. G. G. Ainslie collected a larva of this species on March 25, 1914, in sod land at Orlando, Fla.

Undoubtedly second in importance, and in parts of the South probably first, is the southern corn wireworm (*Monocrepidius vespertinus* (Fab.), fig. 6). Mr. Kelly has found the larvæ of this species

[1] U. S. Dept. Agr., Div. Ent., Notes, v. 2, No. 857, June 6, 1881.

doing considerable damage to wheat at Wellington, Kans. These larvæ attack the wheat in a very unique manner for wireworms. They do not seem to attack the roots, but bore into the cavity of the wheat stem and feed on its inner wall. In some fields as many as one-eighth of 1 per cent of the wheat stems were infested. A large number of these larvæ were placed in a rearing cage on May 6, 1910, and on June 24 four adults were found in the cage. Mr. Kelly found the adult beetles of this species numerous on corn plants in the field from July 3 to August 23. Early in March, 1910, an adult of this species was found in a clump of grass (*Andropogon scoparius*). In 1911 Mr. Kelly succeeded in rearing an adult from a pupa collected among the roots of corn. This adult emerged on July 19. Mr. T. H. Parks, at that time with this office, found the beetles very numerous on young corn at Winfield, Kans., and Oklahoma City, Okla., in June, 1910, and Mr. R. A. Vickery, also of this office, found the beetles very numerous on corn at Brownsville, Tex., in June. Mr. Pergande records[1] the injury to these beetles to cotton at Wetumpka, Ala., and Dr. J. B. Smith found the larvæ injuring beans at Da Costa, N. J.[2] Mr. W. R. McConnell, of this office, found the larvæ of these beetles very numerous in alfalfa fields at Carlsbad, N. Mex.

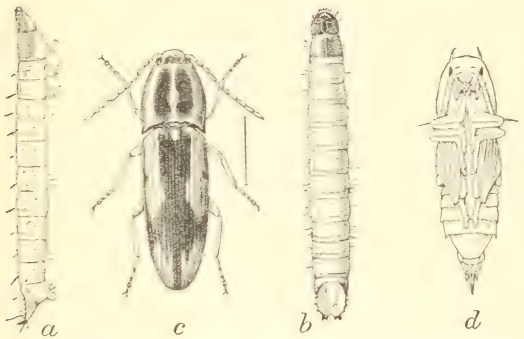

FIG. 6.—The southern corn wireworm (*Monocrepidius vespertinus*): *a*, Side view of larva; *b*, top view of larva; *c*, adult beetle; *d*, pupa. All enlarged. (After Chittenden.)

Owing to the superficial resemblance of the larva of Drasterius to those of Cryptohypnus, the notes in the files of the Bureau of Entomology relative to these two genera are very unreliable. Webster records[3] *Drasterius elegans* Fab. as a serious pest to corn and wheat in Indiana, and Forbes records finding larvæ attacking corn in Illinois.

Drasterius elegans is found throughout the northern half of the United States. *Drasterius amabilis* Lec. is common in the Middle Atlantic States and has also been collected in New England and the Mississippi Valley. All of the beetles in this genus are

[1] U. S. Dept. Agr., Div. Ent., Notes, v. 11, No. 8668, July 11, 1899.

[2] Smith, J. B. Annual Report of the New Jersey State Museum. Including a Report of the Insects of New Jersey, p. 285. Trenton, 1909.

[3] Webster, F. M. Report of observations upon insects affecting grains. *In* U. S. Dept. Agr., Div. Ent., Bul. (Old Ser.) 22, p. 52, 1890.

small, about one-fourth of an inch in length. They are yellow or reddish yellow in color, with more or less black marking. The wireworms are about one-half of an inch long when full grown. They are depressed forms with two prongs on the ninth abdominal segment and are yellowish colored, except the head and first joint, which are brownish.

In the general bureau note files, as well as those of the branch of Cereal and Forage Insect Investigations, are many notes referring to *Drasterius elegans* as predaceous, and also many other notes referring to this species as a pest to crops. None of these notes is at all conclusive, however, and in many cases it is very probable that the form attacking corn and wheat is really the abbreviated wireworm (*Cryptohypnus abbreviatus* (Say)), and it may be that the predaceous form is *Drasterius amabilis*, which the writer finds in many collections under the name *D. elegans*.

Mr. Theodore Pergande, of this bureau, received several larvæ of *Drasterius amabilis* from Manhattan, Kans., on May 3, 1877.[1] He says that these larvæ were found preying on the eggs of *Melanoplus spretus*. On June 20 some of them were killed and eaten by mites, so that nothing but the shell was left. June 25 the other larvæ were completely covered with small mites, so that they could scarcely move, and he believed that probably they would die, also.

These mites to which Mr. Pergande refers were evidently the hypopial stage of some tyroglyphid. In all probability the Drasterius larvæ ate one another, as this is a common occurrence when these larvæ are placed together in a rearing cage. He goes on to say:

> May 31, 1878, another larva of this species about half grown was placed with an Epicauta larva. It has eaten the Epicauta larva. June 18 pupated. July 9 issued.

This note gives a considerably longer pupal period than that observed by the writer at Hagerstown. In another note under the same number there is a record of the finding of a larva of this species within a potato stalk which was infested with *Trichobaris trinotata* Say, and it was probably feeding on these larvæ.

The writer found a very young *Drasterius amabilis* larva eating a pupa of *Meromyza americana* Fitch on July 9, 1912, at Hagerstown, Md. Mr. George Dimmock says that "this species (*D. amabilis*) devours locust eggs."[2]

Drasterius amabilis is very common in western Maryland, where the adults can be found under stones or rubbish from the middle of September until early in the spring.

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[1] U. S. Dept. Agr., Div. Ent., Mem. XII, Note 762P, May 3–June 25, 1877.

[2] Standard Natural History, edited by J. S. Kingsley, v. 2, p. 361. Boston, 1884. "* * * a few of these larvæ are carnivorous, the larvæ of *Drasterius amabilis*, in the United States, being known to devour locusts' eggs."

A larva was collected at the roots of a corn plant, which, however, it did not seem to be damaging, at Hagerstown, Md., in June. This larva pupated on July 6, and the adult emerged July 15. The beetle remained alive without feeding until September 12 of that year. On April 30 a large number of beetles were placed in a small root cage in which corn had been planted. On May 6 all the adults were removed. On July 31 the cage was examined and three full-grown larvæ and one pupa were found. This cage was again examined September 8, and two adults, which, judging from the color and hardness of the integument, were at least a week old, were found.

Pupæ collected in the field emerged July 28, and two larvæ collected July 8 pupated August 10, and one of the beetles emerged August 21, the other August 23.

From the foregoing data it is evident that the life cycle is completed within one season, a very exceptional condition in this group of beetles. The beetles leave their hibernating quarters in early spring and deposit their eggs early in May. The wireworms feed during May and June, and sometimes even throughout July. They start to pupate in early July, continuing pupation throughout July and early August. The pupal stage lasts from 8 to 13 days. The adults emerge from the ground in late summer and in the fall seek hibernating quarters under stones, boards, and rubbish.

Forbes records[1] a species of wireworm (*Asaphes decoloratus* (Say)) as attacking clover in Illinois. This species is also recorded[2] as a pest in New York State.

Mr. Kelly is now investigating an outbreak of a wireworm (*Lacon rectangularis* (Say)) in Kansas. This species has not heretofore been recorded as a wheat pest, but in a recent letter to the writer Mr. Kelly says:

> In one wheat field at Argonis, Kans., in the spring of 1912, as many as 27 per cent of the plants had been bored into and ruined in some spots, with an average of about 18 per cent for the field. Later, however, the damage was much greater, and it was a question whether the grain was worth cutting.

The collared wireworm (*Cebrio bicolor* Fab., fig. 7) has not as yet been recorded as an actual pest to any crops, but as several notes wherein this species has been recorded as feeding on cultivated plants have come to the notice of the writer, and as one of these plants is a cereal, we believe it pertinent to make a short note of this species, that it may be readily recognized should it ever become a serious pest.

The beetles of this species are not now considered as belonging to the same family as the true wireworms, but they are so intimately

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[1] Forbes, S. A. Insect Injuries to the Seed and Root of Indian Corn. Ill. Agr. Exp. Sta., Bul. 44, p. 226, May, 1896.

[2] Comstock, J. H., and Slingerland, M. V. Wireworms. N. Y. Cornell Agr. Exp. Sta., Bul. 33, p. 258–262, Nov., 1891.

related to these insects and the larvæ are so very wireworm-like that they can be treated, from an economic standpoint, as wireworms. The beetle is about three-fourths of an inch long, rather slender, with very prominent scythe-like jaws; the color is brown. The wireworm is cylindrical. The first joint of the body is very large and extends forward under the head, so that the head is partly inserted within it; the last joint is long and thimble-shaped. The wireworm when full grown measures $1\frac{3}{4}$ inches in length and is nearly an eighth of an inch thick. The color is reddish brown.

The genus is recorded by Schiodte[1] as living in moist earth in Europe. In the bureau files is a note[2] by C. V. Riley which records the finding of a pupa at the roots of a grapevine in July, 1874. No locality accompanies the note, which is with other notes made at St. Louis, Mo. On July 11 an adult emerged. In the same files another note[3] records this wireworm as injuring peach and other deciduous tree roots near Fairmont, Cal. In April, 1911, Mr. G. G. Ainslie sent a larva of this species to the writer, stating that he found it feeding on oat plants near Jackson, Miss. He sent two other larvæ of this insect to the writer from Orlando, Fla., where they were found in black, sandy soil.

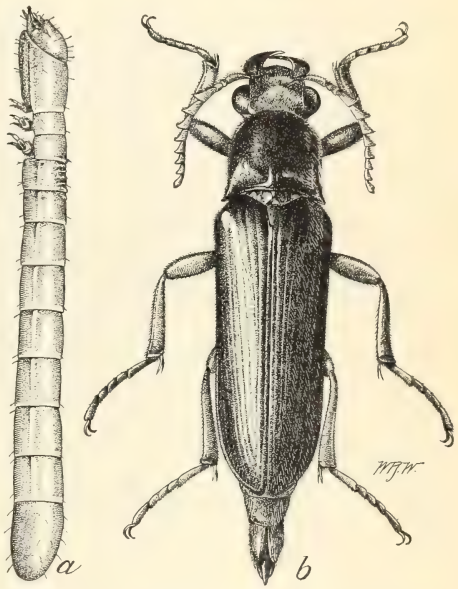

FIG. 7.—The collared wireworm (*Cebrio bicolor*): *a*, Larva; *b*, beetle. Enlarged. (Original.

Another interesting record of a wireworm (*Ludius hepaticus* Germ.) of decidedly minor importance is found in the bureau files.[4] Four larvæ of this species were found attacking cruciferous plants at Georgiana, Fla. Our only other record of this genus is one in which adults were actually reared from larvæ of *Ludius attenuatus* (Say) found in rotten wood; these larvæ were predaceous.

NATURAL ENEMIES.

Probably the most important factor in keeping wireworms in check are the birds. The following list of birds known, by examina-

[1] Schiödte, J. C. De metamorphosi eleutheratorum observationes, pt. 5, p. 530, 1871.
[2] U. S. Dept. Agr., Div. Ent., Mem. VII, No. 350X, July 11, 1874.
[3] U. S. Dept. Agr., Div. Ent., Notes, v. 5, No. 3681, June 24, 1885.
[4] U. S. Dept. Agr., Div. Ent., Notes, v. 4, No. 3570, Feb. 23, 1882.

tion of the crops and stomachs, to feed on Elateridæ, either as larvæ or as adult beetles, is compiled from the records of the Biological Survey of the United States Department of Agriculture:

Franklin gull (*Larus franklini*).
Herring gull (*L. argentatus*).
American black tern (*Hydrochelidon n. surinamensis*).
Wilson snipe (*Gallinago delicata*).
Woodcock (*Philohela minor*).
Upland plover (*Bartramia longicauda*).
Killdeer (*Oxyechus vociferus*).
Bobwhite (*Colinus virginianus*).
California quail (*Lophortyx californica*).
Ruffed grouse (*Bonasa umbellus*).
Mourning dove (*Zenaidura macroura carolinensis*).
Red-shouldered hawk (*Buteo lineatus*).
Red-tailed hawk (*Buteo borealis*).
Broad-winged hawk (*Buteo platypterus*).
Yellow-billed cuckoo (*Coccyzus americanus*).
Black-billed cuckoo (*Coccyzus erythrophthalmus*).
Red-cockaded woodpecker (*Dryobates borealis*).
Downy woodpecker (*Dryobates pubescens*).
Hairy woodpecker (*Dryobates villosus*).
Arctic three-toed woodpecker (*Picoides arcticus*).
Yellow-bellied sapsucker (*Sphyrapicus varius*).
Pileated woodpecker (*Phlaeotomus pileatus*).
Red-headed woodpecker (*Melanerpes erythrocephalus*).
Red-bellied woodpecker (*Centurus carolinus*).
Flicker (*Colaptes auratus luteus*).
Whippoorwill (*Antrostomus vociferus*).
Nighthawk (*Chordeiles virginianus*).
Texan nighthawk (*Chordeiles a. texensis*).
Ash-throated flycatcher (*Myiarchus cinerascens*).
Crested flycatcher (*Myiarchus crinitus*).
Scissor-tailed flycatcher (*Muscivora forficata*).
Kingbird (*Tyrannus tyrannus*).
Arkansas kingbird (*Tyrannus verticalis*).
Cassin's kingbird (*Tyrannus vociferans*).
Phoebe (*Sayornis phœbe*).
Black phoebe (*Sayornis nigricans*).
Say's phoebe (*Sayornis saya*).
Wood pewee (*Myiochanes virens*).
Western wood pewee (*Myiochanes richardsonii*).
Olive-sided flycatcher (*Nuttallornis borealis*).
Western flycatcher (*Empidonax difficilis.*)
Least flycatcher (*Empidonax minimus*).
Traill's flycatcher (*Empidonax trailli*).
Yellow-bellied flycatcher (*Empidonax flaviventris*).
Acadian flycatcher (*Empidonax virescens*).
Horned lark (*Otocoris alpestris*).
Blue jay (*Cyanocitta cristata*).
Steller's jay (*Cyanocitta stelleri*).
California jay (*Aphelocoma californica*).
Crow (*Corvus brachyrhynchos*).
Bobolink (*Dolichonyx oryzivorus*).
Cowbird (*Molothrus ater*).
Yellow-headed blackbird (*Xanthocephalus xanthocephalus*).
Bicolored red-wing (*Agelaius gubernator californicus*).
Red-winged blackbird (*Agelaius phœniceus*).
Meadowlark (*Sturnella magna*).
Baltimore oriole (*Icterus galbula*).
Bullock's oriole (*Icterus bullocki*).
Orchard oriole (*Icterus spurius*).
Rusty blackbird (*Euphagus carolinus*).
Brewer's blackbird (*Euphagus cyanocephalus*).
Purple grackle (*Quiscalus q. quiscula*).
Great-tailed grackle (*Megaquiscalus major*).

English sparrow (*Passer domesticus*).
Vesper sparrow (*Poœcetes gramineus*).
Henslow's sparrow (*Passerherbulus henslowi*).
Sharp-tailed sparrow (*Passerherbulus caudacutus*).
Sandwich sparrow (*Passerculus sandwichensis*).
Ipswich sparrow (*Passerculus princeps*).
Grasshopper sparrow (*Ammodramus s. australis*).
Lark sparrow (*Chondestes grammacus*).
White-throated sparrow (*Zonotrichia albicollis*).
White-crowned sparrow (*Zonotrichia leucophrys*).
Field sparrow (*Spizella pusilla*).
Chipping sparrow (*Spizella passerina*).
Junco (*Junco hyemalis*).
Lincoln's sparrow (*Melospiza lincolni*).
Song sparrow (*Melospiza melodia*).
Fox sparrow (*Passerella iliaca*).
Chewink (*Pipilo erythrophthalmus*).
California towhee (*Pipilo f. crissalis*).
Spurred towhee (*Pipilo m. montanus*).
Cardinal (*Cardinalis cardinalis*).
Rose-breasted grosbeak (*Zamelodia ludoviciana*).
Black-headed grosbeak (*Zamelodia melanocephala*).
Blue grosbeak (*Guiraca cærulea*).
Indigo bunting (*Passerina cyanea*).
Lazuli bunting (*Passerina amœna*).
Painted bunting (*Passerina ciris*).
Dickcissel (*Spiza americana*).

In the desert regions of the Northwest a small lizard (*Phrynosoma douglasii douglasii*, fig. 8), locally called the "sand toad," eats the adult Elateridæ in large numbers. A pair of these small lizards kept in the insectary would eat *Corymbites inflatus* beetles as fast as these could be fed to them. That this is a large part of their natural food is evidenced by the contents of the stomachs of three of these lizards collected at Govan, Wash., on April 24, 1910. In the stomach of lizard No. 1, 60 per cent of the food was ants, 8 per cent click-beetles, and 30 per cent other beetles; in lizard No. 2, 90 per cent was click-beetles and 10 per cent ants; and in lizard No. 3, 75 per cent ants, 15 per cent click-beetles, and 10 per cent other beetles. Several other kinds of these lizards inhabit the more southern desert lands of the West and are usually called "horned toads" in these sections.

In rearing cages wireworms are often infested with small mites (Tyroglyphidæ). The writer received a shipment of Melanotus larvæ from Inman, Nebr., in April, 1912. This material when received was apparently free from any vermin. When examined again, on June 17 of that year, some of the larvæ were found to be badly infested with these mites in the hypopial stage. The mites were so close together on the last two segments of the wireworms' bodies that they gave the impression of an incrustation. On June 24 all the wireworms were infested with these mites. Mr. Pergande also found these mites on larvæ of *Melanotus communis* in his cages at Washington, D. C., in March, 1900.[1] Mr. Banks is of the opinion that these mites are not attacking the wireworms, but merely make use of insects as a ready means of dispersal. He is evidently correct in

[1] U. S. Dept. Agr., Div. Ent., Notes, v. 4, No. 2884, Oct. 9, 1882.

this opinion, as the larvæ in question from Inman, Nebr., are alive at the present writing (October, 1914).

A gamasid was found attached to the body of an adult of *Alaus oculatus* at St. Louis, Mo., by Mr. E. R. Fisher. This mite was under the wing covers.[1] Another mite (*Chelifer alaus*) is recorded[2] as a parasite of the adult *Alaus oculatus*.

The writer has published[3] a record of a fly (*Thereva egressa* Coq.) the larva of which actually attacks and feeds upon wireworms. The larva was found in a wheat field near Pullman, Wash., and when found had its head and first four anterior joints within the body of a wireworm and was eating out the insides. This larva was brought into the insectary and fed upon wireworms, of which it ate usually two a day. On June 10 it pupated, and on June 24 the adult fly emerged. Two other species of Therevidæ (*Psilocephala aldrichii* Coq. and *P. munda Coq.*) were reared by the writer from larvæ taken in the field, associated with wireworms, in the Pacific Northwest. These flies in their larval stages are probably predaceous on elaterid larvæ. Forbes mentions[4] rearing a parasitic fly from an elaterid larva. A Proctotrupes has been reared from an elaterid larva in England by Curtis.[5] In the same work Curtis refers to a similar record by Bierkander.

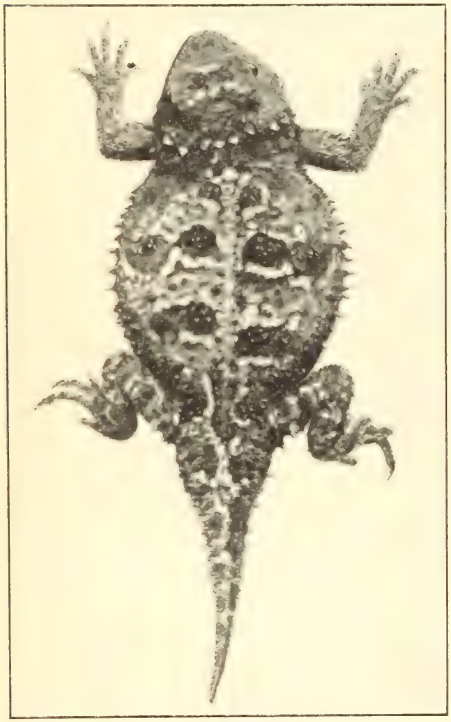

FIG. 8.—A horned toad (*Phrynosoma douglasii douglasii*), an enemy of the western wireworms. (Original.)

[1] U. S. Dept. Agr., Div. Ent., Note 165R, July 21, 1889.

[2] Leidy, J. Remarks on the seventeen-year locust, the Hessian fly, and a Chelifer. *In* Proc. Acad. Nat. Sci. Phila. [v. 29], 1877, p. 260–261, June 19, 1877.

[3] Hyslop, J. A. *Therera egressa*. *In* Proc. Ent. Soc. Wash., v. 12, No. 2, p. 98, June 15, 1910.

[4] Forbes, S. A. Insects Insects to the Seed and Root of Indian Corn. Univ. of Ill. Agr. Exp. Sta., Bul. 44, p. 228, May, 1896.

[5] Curtis, John. Farm Insects, p. 181. London, 1860.

Bierkander obtained through a correspondent a Filaria from a wireworm.[1] The author found a skin of a Melanotus larva firmly attached to the pupa case of a hymenopteron from which the parasite had emerged. The case was very similar to that of *Typhia* sp.

Several records have been made of elaterid larvæ being attacked by fungous diseases. An interesting note is made by Girard[2] in which he records Cordyceps attacking wireworms in Trinidad. A note in the files of this office[3] records a larva of *Agriotes* sp. received from Halifax, Nova Scotia, and placed in a rearing cage in the insectary at Washington, as being found later dead and filled with the mycelium of a fungus which Dr. Flora W. Patterson, of the Bureau of Plant Industry, determined as *Penicillium anisopliæ* Viull. This fungus is known as a parasitic disease of other insects and without doubt killed the larva in question. Comstock records[4] larvæ in his rearing cages being killed by *Metarrhizium anisopliæ*.

The writer found a larva of *Corymbites inflatus* in a rearing cage at the laboratory in Pullman, Wash., which had evidently been killed by a parasitic fungus. It was filled with white mycelium, which distended the body and even grew out between the segments. The specimen was sent in to Washington, but was received in too poor condition for determination.

Early in June, 1913, a large amount of the culture of the white-grub fungus (*Metarrhizium anisopliæ*) was sent to the writer by Mr. J. J. Davis. This material was introduced into a field at Nisbet, Pa. On revisiting the inoculated field on July 14 of that year, a larva of Melanotus was found dead and completely covered with a green fungus. This specimen was sent to Mr. Davis, who tentatively determined the fungus as *M. anisopliæ*. From this culture material the insectary room at the Hagerstown Laboratory became infected, and during the past summer, despite all precautions, at least one-half of the Elateridæ in our rearing cages were killed by this disease.

REMEDIAL MEASURES.

Remedial measures have been given with each of the more important wireworms treated in this paper. Here we wish to report on a number of measures that have been suggested from time to time as efficient in combating these insects. We have actually tried most of these measures, and to prevent repetition of these more or less costly experiments we publish here the results.

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[1] Gardner's Chronicle, London [v. 3], p. 433, June 24, 1843.

[2] Girard, A. Une nouvelle espèce d'Entomophyte. *Cordyceps hunti*, n. sp. (Champignon), parasite d'une larve d'Elateride. *In* Ann. Soc. Ent. France, Bul. des seances, 1895, p. CLXXXI–CLXXXII.

[3] U. S. Dept. Agr., Bur. Ent., Webster Note No. 4751.

[4] Comstock, J. H., and Slingerland, M. V. Wireworms. N. Y. Cornell Univ. Agr. Exp. Sta., Bul. 33, p. 211, November, 1891.

Remedial measures may be classified under three headings: (1) Seed treatment to prevent insects eating the seed; (2) introduction of poisonous or noxious substances into the soil; and (3) cultural methods.

TREATMENT OF SEED.

Under the first head many substances have been used and reported as more or less efficient, among which might be mentioned Paris green and coal tar, gas tar, coal oil, tar, Paris green, and arsenate of lead. In 1884 Webster used kerosene as a treatment of seed corn to protect seed from wireworms. Although his experiment did not apparently impair the vitality of the seed, a farmer who attempted to apply the recommendation claimed that the vitality of the seed was destroyed thereby. In 1888 Forbes treated corn seed with Paris green, and though wireworms fed on corn so thoroughly coated as to be quite green they seemed to experience no ill effects. He also experimented with alcoholic solutions of arsenic and water solutions of strychnine and potassium cyanid.

In the spring of 1911 wireworms were very numerous on the wheat land at Wilbur, Wash., and the writer carried on a series of very extensive experiments to determine the value of some of these substances and also added a few which, to his knowledge, had not been tried before.

Three sacks of wheat (6 bushels) were treated on March 24 with arsenate of lead. Six pounds of insecticide were used for the batch. The arsenate was thinned to the consistency of thick whitewash, with water, and thoroughly mixed into the seed in a large box. The seed, when dry, was very white and well coated. On the same date two sacks (4 bushels) were treated with coal tar. The tar was applied with a paddle, the paddle being first dipped into the tar and then stirred around in the wheat until the seed was well coated. The seed was then mixed with sand and allowed to dry. One sack of wheat was treated with strychnine, 2 ounces of this poison being used to 2 bushels of wheat. The strychnine was dissolved in 2 quarts of hot water and 1 pound of sugar was added as an adhesive. The seed was then soaked in this liquid and allowed to dry. On March 31 all of these treated batches of seed were sown. The sowings were made in plats which were about half a mile long. They were made in an 11-foot wheat seeder, and were arranged as follows:

2 seeder widths of seed treated with strychnine.
2 seeder widths without treatment, as a check.
2 seeder widths of seed treated with coal tar.
4 seeder widths check.
5 seeder widths of seed treated with lead arsenate.
5 seeder widths check.
3 seeder widths of seed treated with coal tar.
9 seeder widths check.
4 seeder widths of seed treated with arsenate of lead.

These plats were carefully staked and examined from time to time, but at no time could any appreciable difference be noted as to their appearance. Wireworms were as numerous in all the treated plats as in the checks. Wheat was very generally attacked and no dead wireworms were found.

A number of wireworms were confined in a large tin cage with wheat treated with strychnine as their only food. After two months these larvæ were still alive and apparently unaffected by the poison, though they ate the poisoned grain.

While these experiments were going on at Wilbur a more intensive series was being carried on at Spokane. Here, instead of wheat, sweet corn was used. These experiments were carried on in a field recently cleared of timber. The soil was quite heavy and very moist. Wireworms were very numerous and apparently quite generally distributed.

On April 5, seed corn was treated in the following manner:

Lot 1. Coal tar was applied very heavily and Paris green dusted onto it until it was quite green.

Lot 2 was treated by soaking for a few minutes in copper sulphate and then drying rapidly in the sun. Several potatoes also were soaked, cut into small pieces, in a saturated solution of strychnine.

This field was all in corn in 1909 and was badly infested with wireworms. In 1910 it was half in wheat on fall plowing and half in potatoes on spring plowing, and was also badly infested this year with wireworms. A plat of each treatment with a check row between each plat was planted on each half of the field. Seventy hills of corn were in each plat. All the plantings were made on April 24. The coal-tar treatment prevented about 90 per cent of the seed so treated from germinating, so this precludes the use, at least as applied to this experiment, of this seed treatment. On May 2 the hills were dug out and the wireworms in each hill counted. Wherever wireworms were present they were attacking the seed. The results of this count appear in Table I:

TABLE I.—*Results of experiments against wireworms with treated seed.*

Row.	Treatment.	Number of hills examined.	Number of wireworms found.	Number of wireworms per hill (average).	Total average number of wireworms per hill for each treatment.
1	Copper sulphate	10	40	4	
11	do	24	138	5.75	4.87
5	Coal tar and Paris green	24			
7	do	24			
2	Check	3			
4	do	24	35	1.458	
6	do	24	40	1.667	
8	do	13	22	1.692	
10	do	24	93	3.875	1.758

From the last experiment we conclude that the use of coal tar and Paris green is not a remedial measure to be recommended. However, Dr. H. T. Fernald has published[1] an account of a series of experiments that seem to reach quite the opposite conclusion, and it is very probable that gas tar will not prevent germination as did the coal tar of our experiments.

The copper-sulphate plat was more severely infested than the check plats, so this treatment is quite useless as an insecticide for wireworms. The potato bait poisoned with strychnine was a failure because the potatoes were allowed to dry up before being placed in the ground.

Mr. G. I. Reeves carried on an experiment at Pullman, Wash., using a commercial tobacco extract applied to the seed corn as a repellent. This experiment was carried on in a root cage. On May 27, 1909, he treated 15 kernels of seed corn by soaking for 24 hours in a solution of commercial tobacco extract, 1 part to 16 parts of water. The seed was dried before planting and was sown with alternate untreated seeds as a check. Wireworms were introduced at the time of seeding and also on June 2. The experiment was discontinued on June 10, and all the seed carefully examined. Of the treated seeds, eight were eaten into by wireworms, while nine of the untreated seeds were destroyed. It is very evident from this experiment that tobacco solution as a repellent is quite useless, at least for wireworms.

Soaking the seed in formalin has been suggested as a means of repelling wireworms. This measure is quite useless. In the regions of the Pacific Northwest where the author was studying severe wireworm outbreaks nearly all the seed wheat had been treated with formalin as a means of preventing the development of smut fungus.

Mr. O. A. Johannsen and Miss Edith M. Patch have published[2] the results of a series of experiments carried on in Maine. They treated seed corn with tar and Paris green, and with arsenate of lead, and found both of these treatments inefficient.

SOIL TREATMENT.

The second group of remedial measures—soil treatment—has received considerable attention. Experiments with soil fumigants are now being carried on by the writer, but as the methods have not as yet been placed on a practical basis this matter will not be treated herein.

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[1] Fernald, H. T. A new treatment for wireworms. *In* Jour. Econ. Ent., v. 2, No. 4, p. 279–280, August, 1909.

[2] Johannsen, O. A., and Patch, Edith M. Insect Notes for 1911. Maine Agr. Exp. Sta., Bul. 195, p. 229–248, December, 1911.

Webster carried on experiments at Cedarville, Ohio, in 1894 to determine the effectiveness of kainit as an insecticide. The fertilizer was applied at the rate of 500 pounds to the acre without any effect whatever. He also carried on a series of experiments at La Fayette, Ind., in 1889, to test the efficiency of an often-recommended substance—table salt. Pots were used in these experiments, and table salt applied to the surface and washed in with water. Three dosages were used at the rate of about 500 pounds, 1,000 pounds, and 25,000 pounds per acre, respectively, and in no case were wireworms killed by the application.

The Maine experiment station has tried a patented preparation composed largely of slaked lime, a "soil fungicide," and tobacco dust, applied to the hills in cornfields infested with wireworms, and has found all of these treatments quite useless. Experiments[1] with chlorid of lime, gas lime, chlorate of potash, bisulphid of carbon, crude petroleum, kerosene, and emulsions of crude petroleum and kerosene, applied to the soil, have demonstrated that none of these substances is of practical value in destroying wireworms. However, the use of petroleum products as soil sterilizers is suggestive, and will be further investigated.

Mr. J. J. Davis[2] has found that a soil fumigant highly recommended by some English entomologists is quite useless in combating *Limonius confusus*.

CULTURAL METHODS.

The third group of remedial measures—cultural methods—is the only one which so far has been actually proved to be of practical value.

Flooding land where irrigation is practiced would be of little avail unless long continued, as we have records of severe outbreaks of wireworms on land in Indiana that is annually overflowed by the rivers. Fall plowing is of but little use in combating these insects. The cornfields so severely attacked by the wheat wireworm at Bridgeport last year had been plowed in the spring. The garden patch, however, was fall plowed, and potatoes on this patch were absolutely destroyed by wireworms. Another piece of fall-plowed land on another part of the farm planted to corn was practically free from worms, which illustrates how easily faulty conclusions can be arrived at, with insufficient data. Mr. O. A. Johannsen and Miss Edith Patch record observations made at Monmouth, Me., in 1911, wherein a field was plowed after the ground

[1] Comstock, J. H., and Slingerland, M. V. Wireworms. N. Y. Cornell Univ. Agr. Exp. Sta., Bul. 33, November, 1891.

[2] Davis, J. J. Insect notes from Illinois for 1909. *In* Jour. Econ. Ent., v. 3, No. 2, p. 182, April, 1910.

had been stiffened by frost in the fall, and which was so badly infested the following spring that the crops were absolutely destroyed.

The fatality to the beetles caused by the destruction of the pupal cell in the fall has been apparently somewhat overdrawn. In our cages at the field station at Hagerstown, Md., we had, in March, 1914, many adults of *Agriotes mancus* alive in cages wherein they were subjected to outdoor weather conditions. These adults were removed from their pupal cells during September, 1913.

Two other remedial measures have been suggested from time to time, the first of which is trapping the larvæ in potato and other vegetable baits and hand killing; the second is killing the adults with poisoned bait of several kinds—clover, sweetened liquids, bran mash, potatoes and other vegetables, and rape cake. Miss Ormerod found a true rape-seed cake quite useless, but reports[1] "Kurrachee cake," made from mustard seed, as killing the larvæ which fed upon it. These methods have been found very inefficient, and even were they successful in killing the insects they would be impractical so far as the extensive cereal and forage crops are concerned.

[1] Proc. Ent. Soc. London, 1882, p. xix.

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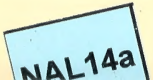
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